METHOD OF INJECTING/EXTRACTING CONTROL CELLS IN AN ASYNCHRONOUS TRANSFER MODE (ATM) NETWORK

BACKGROUND OF THE INVENTION

1. Technical Field:

The invention relates generally to Asynchronous Transfer Mode (ATM) networks wherein a source ATM device and a destination ATM device are connected by multiple intermediary network switching nodes, and relates in particular to a method for injecting control cells such as Operation And Maintenance (OAM) cells into the source-to-destination connection at an injection switching node and extracting the control cells from the connection at an extraction switching node.

2. Description of the Related Art:

A connection is established in an ATM network from a source ATM device to a destination ATM device by multiple intermediary switching nodes. Incoming cells into a switching node are automatically routed to the next switching node of the connection. To this end, each cell includes an ATM header and a payload. An ATM protocol engine in the switching node identifies an incoming ATM cell utilizing a lookup table.

Upon a determination that an incoming cell is a valid cell ("valid" meaning belonging to an existing connection), the protocol engine performs traffic management functions related to traffic policing, congestion management, priority management, etc., and queues the cell in an appropriate queue. A scheduler

utilizes priority-based scheduling procedures to select queues from which cells are transmitted. Upon selection by the scheduler, the cells are dequeued from their respective queues.

Prior to transmission of the cell from the switching node, the protocol engine adds routing labels to the cell including a switch routing label (SRL) and a protocol engine correlator (PEC). A cell formatted in accordance with such labeling by the protocol engine is processed within the switching node and will be referred to hereafter as a "labeled cell".

The SRL contains either the identity of the destination blade explicitly, or a pointer to a translation table located in the switching device that contains the explicit destination blade identity. The PEC is a pointer utilized by the protocol engine of an output adapter of the switching node to identify the connection to which the cell belongs. The protocol engine in the output adapter receives the cell from a switching interface within the switching node. Similar to the input protocol engine, the processing performed by the output protocol engine on the cell includes: identifying the incoming cell by performing a lookup on the appended protocol engine correlator; performing traffic management functions; queueing the cell in the appropriate queues; dequeueing the cell in accordance with a scheduler. In addition, the output protocol engine removes the appended labels, swaps the ATM label, and transmits the cell on the connection to the appropriate destination ATM port(s).

Conventionally, transmitting control cells, such as Operation And Maintenance (OAM) cells, from an ATM switching node to another ATM switching node of the connection, requires transmission of control messages between the two switching nodes using specific hardware resources such a microprocessor dedicated to such a task in each switching node. However, such a solution is inefficient both in terms of cost and overhead devices inasmuch as it requires incorporation of microprocessors on the adapter cards of the switching nodes in addition to the Application Specific Integrated Circuit (ASIC) modules that are utilized to route non-control ATM cells.

SUMMARY OF THE INVENTION

A method and system for injecting a control cell into an Asynchronous Transfer Mode (ATM) data connection between a source ATM device and a destination ATM device are disclosed herein. A control cell is injected into the connection by the control point of an injection switching node. The control cell injection method includes generating a control cell composed of a payload and an ATM header containing the input VP/VC of the connection in order to constitute an ATM cell. A switch routing label (SRL) and a protocol engine correlator (PEC) are added to the control cell to label the control cell. An injection flag is set in the labeled control cell for indicating to the protocol engine of the control point that the cell is a control cell to be injected into the connection.

A second aspect of the invention relates to extracting a control cell from the ATM data connection. The method includes determining within an extraction switching node, whether an incoming cell includes an extraction condition. If the incoming cell includes an extraction condition, a control flag is set in the control block of the incoming cell that indicates that it is a control cell to be extracted. A switch routing label corresponding to the control point (CP SRL) and a reserved static protocol engine correlator (SPEC) are added to the control cell before it is transmitted to the switch of the extraction switching node, such that the cell is extracted on the downside of the switching node.

All objects, features, and advantages of the present invention will become apparent in the following detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the invention will be better understood by reading the following more particular description of the invention in conjunction with the accompanying drawings wherein:

Fig. 1 illustrates an ATM network in which a preferred embodiment of the present invention is applicable;

Fig. 2 is a block diagram depicting a switching node in which a preferred embodiment of the present invention is applicable;

Fig. 3 illustrates a cell injection system and a cell extraction system in accordance with a preferred embodiment of the present invention;

Fig. 4 is a block diagram depicting a system for injecting a control cell within an injection switching node in accordance with a preferred embodiment of the present invention;

Fig. 5A and **5B** are block diagrams illustrating a system for processing and extracting a control cell within an extraction switching node in accordance with a preferred embodiment of the present invention; and

Fig 6 is a flow diagram depicting the sequential steps of the process implemented for processing a previously injected control cell in accordance with a preferred embodiment of the present invention

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures wherein like reference numerals refer to like and corresponding parts throughout, and in particular with reference to **Fig. 1** shows an example of an ATM network **10** implementing the system according to the invention, and comprising four switching nodes **12**, **14**, **16** and **18** being respectively connected to local consoles **20**, **22**, **24** and **26**. Each switching node is composed of a Control Point (CP) blade such as CP blades **28** of switching node **12**, a plurality of adapter blades such as adapter blade **30** in node **10**, which provide the physical attachments to network devices such as the other switching nodes or the user workstations and a switch fabric providing cell switching between its ports on which are attached the adapter blades. The local console attached to the CP blade in each node is used for the network and control management.

It is assumed that a connection is established between a source ATM device attached to switching node **12** and a destination ATM device attached to switching node **18** through intermediary switching nodes **14** and **16**. According to the principles of the invention, control cells can be injected into this connection by control point **28** of node **12** and can be extracted by control point **29** of node **18**, utilizing extant hardware resources included in each of said nodes. It must be noted that the control cells could also be injected by a control point of any intermediary switching node such as node **14**, and could be extracted by any subsequent intermediary switching node such as node **16**.

With reference now to **Fig. 2**, there is illustrated a
block diagram depicting a switching node in which a
preferred embodiment of the present invention is
applicable. Specifically, **Fig. 2** shows the internal
structure of each switching node, each adapter blade **30**,
and each CP blade **28**. As depicted in **Fig. 2**, the adapter
blades and CP blades share the same flow structure. One
of the two ASIC modules used in each blade is a Common
ATM Data mover (CAD) module **32** which performs functions
related to the data flow. The other ASIC device is a
Common ATM Processor (CAP) module **34** that performs the
necessary ATM processing. As illustrated in **Fig. 2**, each
CAD **34** is connected to a switch device **36**.

Each of CAD modules **34** and CAP modules **32** is split
into two parts, an UP side for the receive flow and a DN
side for the transmit flow. The CAD UP side receives
data from transmitted from physical links and stores them
in a data storage. For each cell received, CAD UP
exchanges information such as VP, VC and cell buffer ID
with the CAP UP for cell processing. The CAP UP sends
back information needed to forward the cell through
switch **36** via the CAD UP. This cell forwarding
information is found in a control storage delivered by
the CAP UP side. Note that switch **36** connects blades UP
to blades DOWN and forwards cells from an input port to
an output port.

The CAD DN side receives data from switch **36** and
stores it in a data storage. For each cell received, the
CAD DN side exchanges information such as Protocol Engine
Correlator (PEC) and cell buffer ID with the CAP DN for
cell processing. The CAP DN side returns information

needed to forward the cell to the correct destination port and ATM connection via the CAD DN side. CP blades includes the same structure as adapter blades, wherein the control point is an ATM device of the ATM network.

Turning now to **Fig. 3**, there is illustrated a cell injection system and a cell extraction system in accordance with a preferred embodiment of the present invention. As shown in **Fig. 3**, an ATM connection **40-40'** is setup from a first switching node **41** called the injection node to a second switching node **43** called the extraction node through an ATM network **10**. The injection of control cells into ATM connection **40-40'** is performed by a control point **45** of injection node **41** while extraction of the control cells is performed near a control point **47** of extraction node **43**.

With reference now to **Fig. 4**, there is illustrated a block of a control cell injection system in accordance with a preferred embodiment of the present invention. The control cell injection system depicted in **Fig. 4** is utilized for injecting an OAM control cell **59** in a particular ATM connection at an injection switching node **49**. The particular ATM connection is characterized within injection switching node **49** by the input port address in the switching node, the input ATM label (VP-VC in), the output port in the switching node, and the output ATM label (VP-VC out).

When a non-control ATM cell belonging to the ATM connection is received by an input blade of injection switching node **49**, an input protocol engine **51** identifies the incoming cell using a lookup table **48** with the input

port and input ATM label designation of the cell. The
lookup returns relevant traffic parameters and routing
parameters. Such routing parameters comprise a Switch
Routing Label (SRL) processed by a switch device **44** of
injection switching node **49** to route the cell to an
appropriate output blade and a Protocol Engine Correlator
(PEC) that is utilized by an output protocol engine **53** of
the designated output blade to identify the cell received
from switch device **44**.

To inject OAM cell **59** (or any type of other control
cells known to the person skilled in the art such as
Resource Management (RM) cells) on the ATM connection, a
CP **42** transmits OAM cell **59** and labels OAM cell **59** with
the following: an input VPI-VCI of the designated ATM
connection; the routing labels of the defined connection
(SRL and PEC); the Payload Type Indicator (PTI) field of
the ATM header defining the cell as an OAM cell
(respectively RM cell); and a flag indicating the cell is
an injected cell.

In response to receiving input OAM control cell **59**
generated and characterized by CP **42**, input protocol
engine **51** (located within the control point blade) reads
the injection flag and bypasses ATM label lookup **48** in
response thereto. The injection flag is encoded into and
read from the header of the labeled control cell. After
bypassing ATM lookup **48**, protocol engine **51** performs an
enqueue function **55** in which the labeled control cell is
assigned into queues **50** and a dequeue function **57** is
performed. Then, the injection flag is again read by
protocol engine **51** to bypass the routing label appending
function **61**. OAM cell **59** is thus directly transferred to

a XMIT unit **52** for transmission to switch **44**. Prior to transmitting OAM cell **59** to switch **44** protocol engine **51** removes the injection flag from the header of OAM cell **59**.

Upon receipt by switch **44**, OAM cell **59** has exactly the same processing information in its header as a conventional non-control ATM cell within the ATM connection, except that this information (SRL, PEC) has been assigned by control point **42** of injection node **49**. After being switched through the switch fabric of switch device **44**, the data flow process utilized to process the injected OAM cell is the same as that utilized for non-control ATM traffic cells. As shown in **Fig 4**, upon transmission from an output port of protocol engine **53** to the ATM network, OAM cell **59** includes the OAM payload and the swapped label (ATMH OAM).

Turning now to **Fig. 5A** and **5B**, block diagrams are utilized to illustrate a control cell processing system in accordance with a preferred embodiment of the present invention. During initialization of a switching node **69**, a CP (not depicted) within switching node **69** determines and defines multiple static routes from all input ports of switching node **69** that lead to the control point. In doing so, the CP defines two static parameters for all input blades of switching node **69** including the following: the SRL (referred to hereinafter as CP_SRL) that corresponds to the output blade to which the control point is attached (this parameter is common to all blades), and a blade identifier (referred to hereinafter as B_id), that is, in accordance with a preferred

embodiment of the invention, the encoded value of the
blade (this parameter is blade-specific).

The blade identifier will be used by a protocol
engine **71** of an input blade to generate a particular PEC
that will be denominated hereinafter as a Static PEC
(SPEC). The SPEC is encoded with the identity of the
input blade (B_id) and the identity of an input port in
the input blade. For example, a possible SPEC encoding
may take the form: SPEC = b'00 0000 00PP BBBB' where
BBBB = B_Id and PP = encode_port. Such encoding permits
the CP of switching node **69** to account for possible
intra-node routes formed from 16 blades, wherein each
blade includes 4 ports, and that standard PECs are 14
bits wide. One skilled in the art will recognize that
any alternate encoding may be chosen without departing
from the scope of the invention.

The CP then reads a PEC table of the output blade to
which the CP is attached to identify table entries that
corresponding to the SPECs utilized in switching node **69**.
In the previous SPEC example, the CP designates **64**
entries in the PEC table corresponding to the **64** static
routes from any of the **64** ports of switching node **69** to
control point **82**. Each of the SPEC entries specifies
that the cell received with the particular PEC has been
extracted. This extraction information will be
utilized, as shown hereafter by an output protocol engine
81 of CP blade **82**, to modify its conventional ATM traffic
cell processing when handling an extracted cell. It is
important to note that the SPECs can not be utilized by
ATM connections within CP blade **82** (the SPECs are

dedicated and statically allocated to the extraction process).

When an ATM cell **79** is received at an input port in an input adapter of extraction switching node **69**, protocol engine **71** determines whether cell **79** is to be extracted. In making such a determination, various extraction conditions may be used, the simplest being a per connection flag indicating that all received OAM cells of the connection are to be extracted. Protocol engine **71** sets a control flag in the control header of cell **79** to be extracted and performs its regular process from MPX unit **76** to XMIT unit **72**. However, instead of appending the labels conventionally utilized for ATM user traffic as found in the connection control blocks, protocol engine **71** appends a SRL corresponding to the switch output port to which the control point is connected (CP_SRL) and further appends a reserved Static Protocol Engine Correlator (SPEC) using the Blade identifier B_Id information to the extracted OAM cell **79**.

In contrast to the dynamic process by which the conventional connections are established, CP **82** establishes static paths during initialization of switching node **69**. Thus, CP **82** defines for each input adapter, a register that contains a designated SRL (CP SRL) which provides a path to reach CP **82**. In addition, CP **82** designates a particular SPEC identifying the input adapter. When cell **79** is transferred by XMIT unit **72** to switch **74**, it includes the CP SRL and the SPEC as a header for the OAM payload as illustrated in **Fig. 5A**.

Switch **74** routes labeled cell **79** to the CP adapter
as illustrated in **Fig. 5B**. Protocol engine **81** performs
the routing label (PEC) lookup function **84**, resulting in
a determination by protocol engine **81** that cell **79** has
been extracted to CP **82** (this extraction information is
written by CP **82** in the entries of lookup table **84** that
correspond to the reserved labels used to extract the
cells). Protocol engine **81** then flags cell **79** by setting
an extraction flag in the cell header. After queuing and
dequeuing by means of queues **80**, the extraction flag is
used by protocol engine **81** to bypass the remove routing
label/ATM label swap function and deliver cell **79**
directly to XMIT unit **88** so that cell **79** is received by
CP **82** after DMPX unit **86** containing only the incoming ATM
label (input VP/VC) and the source and input adapter
identifications encoded in the SPEC. This labeling
allows CP **82** to identify the connection to which the
received extracted cell belongs.

With reference now to **Fig 6**, there is depicted a
flow diagram representing the sequential steps of the
process implemented for processing a previously injected
control cell in accordance with a preferred embodiment of
the present invention. When a cell has been identified
(step **70**) by the protocol engine of the input adapter (if
not identified the cell is discarded), it is checked to
determine whether or not the cell is to be extracted as a
control cell (step **72**). If not, the switch routing label
(SRL) and the protocol engine correlator (PEC) of the
connection to which the cell belongs are appended to the
cell as for all traffic cells (step **74**). If the
extraction condition exists, a special switch routing
label to the control point of the switching node (CP SRL)

and a reserved static protocol engine correlator (SPEC) are appended to the cell (step **76**).

In any case, the cell is then routed by the switch of the switching node (step **78**) and in the output blade, a PEC lookup is performed (step **80**) whose result indicates wether or not the cell contains an extraction flag (step **82**). If not, the cell is processed regularly: a label swap is performed (step **84**) and the routing labels (SRL and PEC) are removed (step **86**) prior to cell transmission (step **88**). Otherwise, the cell is transmitted to the control point of the switching node (step **90**) with its header including CP SRL and SPEC (encoding the source port and the source blade) which have not been removed as in a normal cell and are used by the control point to identify the connection from which the cell was extracted.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.